Explosion Hazards Ltd

ATEX simplified

“A path through the mire”

White Paper

ATEX Simplified White Paper

Introduction

A statement from the Irish factories Act in 1955 sets out its legal position on dust explosions:

"In the case of a process giving rise to dust of such a character and to such an extent as to be liable to explode on ignition, then, unless the plant is so constructed as to withstand the pressure likely to be produced by any such explosion, all practical steps shall be taken to restrict the spread of the effects of such an explosion by the provision, in connection with the plant, of chokes, baffles, and vents, or other effective appliances".

This is a very simple statement of fact which is still true today but now we have a dearth of legislation which attempts to harmonise the activities of EU member states and specify the minimum EHSR (essential health and safety requirements) of the process, its equipment and protective measures employed in it.

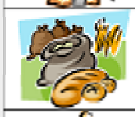
The **ATEX directive** consists of two EU Directives.

- The responsibility of the User: the ATEX 137 *workplace* directive 99/92/EC, Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres.
- Harmonised requirements for the Manufacturer to sell to the User: the ATEX 95 *equipment* directive 94/9/EC, Equipment and protective systems intended for use in potentially explosive atmospheres, these are supported by EN standards.

As of July 2006, organisations in EU must follow the directives to protect employees from explosion risk in areas with an explosive atmosphere.

ATEX gets its name from the French title of the 94/9/EC directive: *Appareils destinés à être utilisés en **AT**mosphères **Ex**plosibles*

Table 1.1 examples of explosion hazards in various branches

	Branch	Explosion hazard
	Chemical industry	Flammable gases, liquids and solids are converted and processed in many different processes in the chemical industry. These processes may give rise to explosive mixtures.
	Landfill tips and Civil Engineering	Flammable landfill gases may arise in landfill tips. Elaborate technical arrangements are needed to avoid uncontrolled gas emission and possible ignition. Flammable gases from various sources may collect in poorly ventilated tunnels, cellars, etc.
	Power generating companies	Lump coal, which is not explosive in mixture with air, may be converted in the conveying, grinding and drying processes into coal dusts capable of forming explosive dust/air mixtures.
	Waste disposal companies	When waste waters are treated in clarification plants, the gases generated may form explosive gas/air mixtures.
	Gas suppliers	Explosive gas/air mixtures may be formed when natural gas is released, e.g. by leakage.
	Wood-working industry	Wood-working gives rise to wood dusts. These can form explosive dust/air mixtures, e.g. in filters or silos.
	Paint-spraying operations	The overspray generated in paint spray bays and the solvent vapours released may give rise to explosive atmospheres when mixed with air.
	Agriculture	Biogas production plants are operated on some farms. Explosive biogas/air mixtures may arise if the gas is released, e.g. by leakage.
	Metal-working operations	When shaped parts are manufactured from metals, explosive metal dusts may be produced during surface treatment (grinding). This particularly applies to light metals. These metal dusts may give rise to an explosion hazard in dust collectors.
	Food and feedstuffs industry	Explosive dusts may arise during transport and storage of grain, sugar, etc. If they are exhausted and collected by filtering, explosive atmospheres may arise in the filter.
	Pharmaceutical industry	Alcohols are often used as solvents in the production of pharmaceuticals. Agents and auxiliary materials that give rise to dust explosions, such as lactose, may also be used.
	Refineries	The hydrocarbons handled in refineries are all flammable and, depending on their flash point, may give rise to explosive atmospheres even at ambient temperature. The area around oil processing plant is generally regarded as a place where explosive atmospheres may occur.
	Recycling operations	Processing of waste for recycling can give rise to explosion hazards, e.g. from cans or other containers of flammable gases and/or liquids that have not been completely emptied or from paper or plastic dusts.

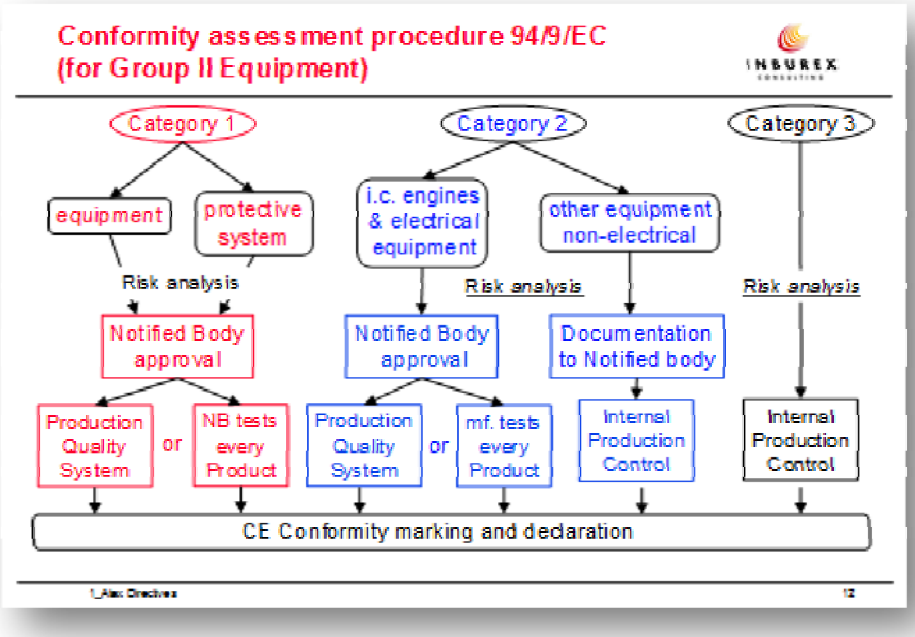
Employers must classify areas where hazardous explosive atmospheres may occur into zones. The classification given to a particular zone, and its size and location, depends on the likelihood of an explosive atmosphere occurring and its persistence if it does.

Areas classified into zones (0, 1, 2 for gas-vapour-mist and (by placing a digit 2 in front for dust) 20, 21, 22 for dust) must be protected from effective sources of ignition. Equipment and protective systems intended to be used in zoned areas must meet the requirements of the directive.

Marking of Equipment - Directive 94/9/EC (Annex II, 1.0.5)

- Name/address manufacturer
- Marking + if appropriate notified body number
- designation of series or type
- serial number, year of construction
- Symbol + EEx
- Category (M1 / M2 / 1 / 2 / 3)
- for equipment-group II, 'G' (gas) and/or 'D' (dust)
- Explosion / Ignition protection symbol + (if appropriate) Gas group
- Temperature Class or Temperature

Example: EEx 2 G d IIA T4



Certification ensures that the equipment or protective system is fit for its intended purpose and that adequate information is supplied with it to ensure that it can be used safely.

See: ATEX 95 Guidance

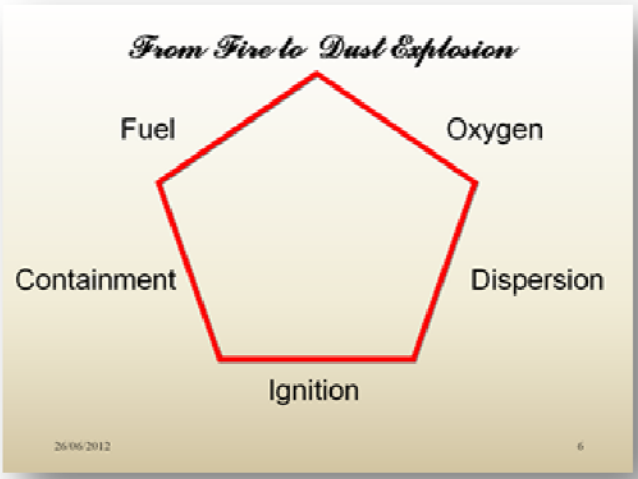
Manufacturers who apply its provisions and affix the CE Mark and the Ex marking are able to sell their equipment anywhere within the European union without any further requirements being applied with respect to the risks covered being applied. The directive covers a large range of equipment, potentially including equipment used on fixed offshore platforms, in petrochemical plants, mines, flour mills and other areas where a potentially explosive atmosphere may be present.

The ATEX Non-binding Guide of Good Practice is primarily intended to assist Member States in drawing up their national policies for the protection of the health and safety of workers.
Its aim is thus to enable the *employer*, particularly Small and Medium Enterprises (SME's), to perform the following explosion protection functions:

- to identify hazards and assess the risks;
- to lay down specific measures to safeguard the safety and health of *workers* at risk from *explosive atmospheres*;
- to ensure a safe working environment and appropriate surveillance during the presence of *workers* in accordance with the risk assessment;
- to take the necessary steps and make the necessary arrangements for coordination when several firms are operating at the same workplace;
- to produce an explosion protection document.

Virtually all branches are affected, since hazards from *explosive atmospheres* arise in a wide range of processes and operations. Examples are given in Table 1.1.

In very broad terms, there are three preconditions for the directive to apply: the equipment; a) must have its own effective source of ignition; b) be intended for use in a potentially explosive atmosphere (air mixtures); and c) be under normal atmospheric conditions. For dust you must add the extra components of Containment and Dispersion.



Fire: Combustion of a fuel which is mixed with air by diffusion/turbulence

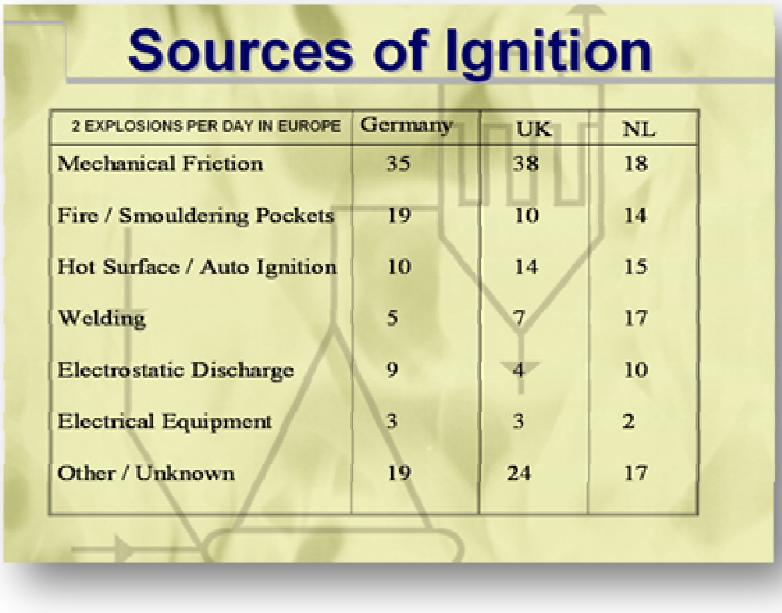
Explosion: Combustion of a premixed gas cloud with pressure build up

The directive also covers components essential for the safe use and safety devices directly contributing to the safe use of the equipment in scope. These latter devices may be outside the potentially explosive environment.

Manufacturers/suppliers (or importers, if the manufacturers are outside the EU) must ensure that their products meet essential health and safety requirements and undergo appropriate conformity procedures. This usually involves testing and certification by a 'third-party' certification body (known as a Notified Body e.g. Baseefa, Sira, Intertek. Gexcon, Lloyd's,) but manufacturers/suppliers can 'self-certify' Category 3 equipment (technical dossier including drawings, hazard analysis and user's manual in the local language) and Category 2 non-electrical equipment but for Category 2 the technical dossier must be lodged with a notified body. Once certified, the equipment is marked by the 'CE' (meaning it complies with ATEX and all other relevant directives) and 'Ex' symbol to identify it as approved under the ATEX directive. The technical dossier must be kept for a period of 10 years.

Ignition:

For combustion to happen you normally need; a hazard (gas dust or vapour) oxygen (in sufficient quantities) and an ignition source.



2 EXPLOSIONS PER DAY IN EUROPE	Germany	UK	NL
Mechanical Friction	35	38	18
Fire / Smouldering Pockets	19	10	14
Hot Surface / Auto Ignition	10	14	15
Welding	5	7	17
Electrostatic Discharge	9	4	10
Electrical Equipment	3	3	2
Other / Unknown	19	24	17

Hazards:

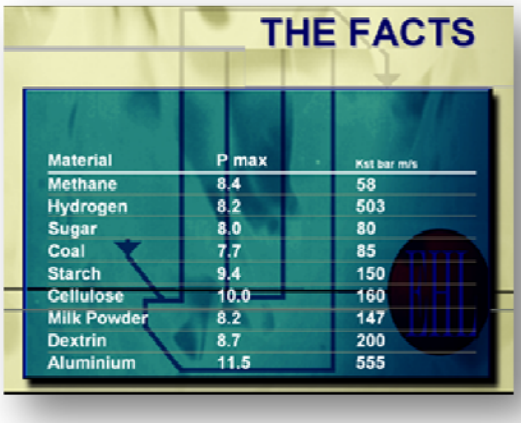
Over 70% of products in industry are hazardous. Dusts can be worse than gases as they can cause a worse secondary explosion e.g. outside a vented vessel.

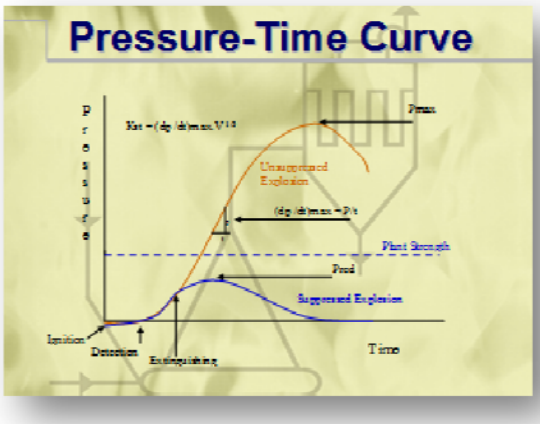
Explosions by Industry

Foodstuff (Inc Animal feed)	25%	42%	51%
Wood/Paper	34%	12%	19%
Metal	13%	14%	7%
Plastic	13%	5%	6%
Coal/Peat	9%	5%	6%
Other	6%	22%	11%

Data:

Methane can have a Pmax of 8.4barg with a maximum rate of pressure rise Kg of 58 barm/s where has Hydrogen may have a Pmax of 11 bar with a Kg of 555 bar m/s. Compare this with Flour with a Pmax of 8.0 barg and a Kst of 100 bar m/s or worse Aluminum 11.5 barg and a Kst of 555 bar m/s.


THE FACTS
Material | P max | Kst bar m/s
Methane | 8.4 | 58
Hydrogen | 8.2 | 503
Sugar | 8.0 | 80
Coal | 7.7 | 85
Starch | 9.4 | 150
Cellulose | 10.0 | 160
Milk Powder | 8.2 | 147
Dextrin | 8.7 | 200
Aluminium | 11.5 | 555



Using Flour as an example, A dust above **LEL** (lower Explosion Limit) e.g. 60g /m3, ignites from an appropriate ignition source (Minimum Ignition Energy 100mj); this grows spherically as it consumes more unburnt fuel, relative to the volume the pressure increase proportionally to the temperature faster in a smaller vessel and slower in larger vessels (dp/dt max 160 bar m/s Kst in a 1m3 volume @ a concentration of 500g/m3) until it reaches the vessel wall after consuming all the available fuel it has reached its **Pmax** maximum Explosion Pressure for Flour 9.7 barg. Now if the vessel is only 0.4 barg then the roof of the vessel will rupture so we need to apply a protection system either Venting or suppression to keep the pressure Pred below 0.4barg.

Bread Flour from **Gestis Dust-Ex** website

characteristic			
Particle size <500 µm [% by weight]	94		
Particle size <250 µm [% by weight]	72	100	
Particle size <125 µm [% by weight]	33		
Particle size <63 µm [% by weight]	14		100
Particle size <32 µm [% by weight]	7		
Median Value [µm]	180	<180	<63
Moisture Content [% by weight]	4,3		
Lower Ex-Limit [g/m^3]			60
Max.Ex-Overpressure [bar]			9,7
K_{St} Value [bar m/s]			63
Explosibility	St 1		St 1

The fineness and moisture content indicated in the first column refer to the state of the dust sample as delivered. The "delivered" state may also be identical to the tested state.

The listed combustion and explosion characteristics always apply only to the dust with the conditions described in the same column.

The data of GESTIS-DUST-EX are compiled and updated carefully. Nevertheless, any liability is excluded (cf. limits of applicability).

Ignition Temperature BAM [°C]	380		380	
Combustibility BZ	2	2		

Zones:

Frequency that a product can be dispersed in air above its LEL

Layers, deposits and heaps of dust must be considered as any other source which can form an explosive atmosphere

“Normal operation” - situation when installations are used within their design parameters (i.e. including start up and shut down)

Zone 20 *Continuously*, long periods or frequently e.g. greater than 1000 hours per year

Extent inside process vessel (Bounded by equipment wall) e.g. hoppers, silos, cyclones, filters, blenders, mills, dryers, bagging equipment and dust transport systems

Zone 21 Occasionally in *normal* operation e.g. 10 to 1000 hours per year

Extent outside dust containment filling / emptying points without extract, immediate vicinity access doors frequently used when dust cloud present, dust layers frequently disturbed forming explosive dust air mixture extent inside equipment, silos, filters where dust cloud occurs only occasionally

Zone 22 Not likely in *normal* operation, but if so, only for a short period e.g. Less than 10 hours per year likes a shutdown or maintenance period.

Typically 1 m around a possible identified source of release, non-confined zone 21 always surrounded by zone 22, outlets from bag filter vents, vicinity access doors / openings infrequently used, bag storage areas (bag breakage), filling / emptying points with extract / ventilation, areas with dust layers that can form explosive dust clouds

Non-hazardous: layers removed by cleaning before explosive dust / air mixture formed

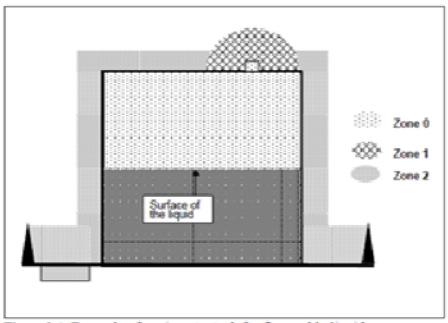


Figure 3.4: Example of zoning at a tank for flammable liquids

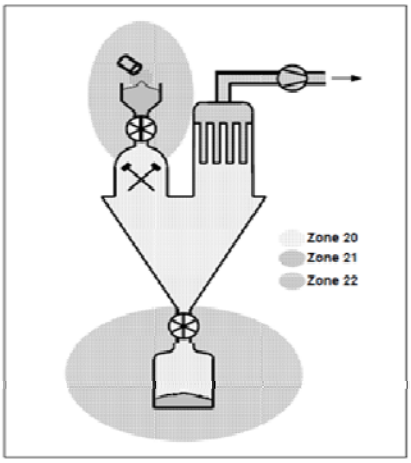
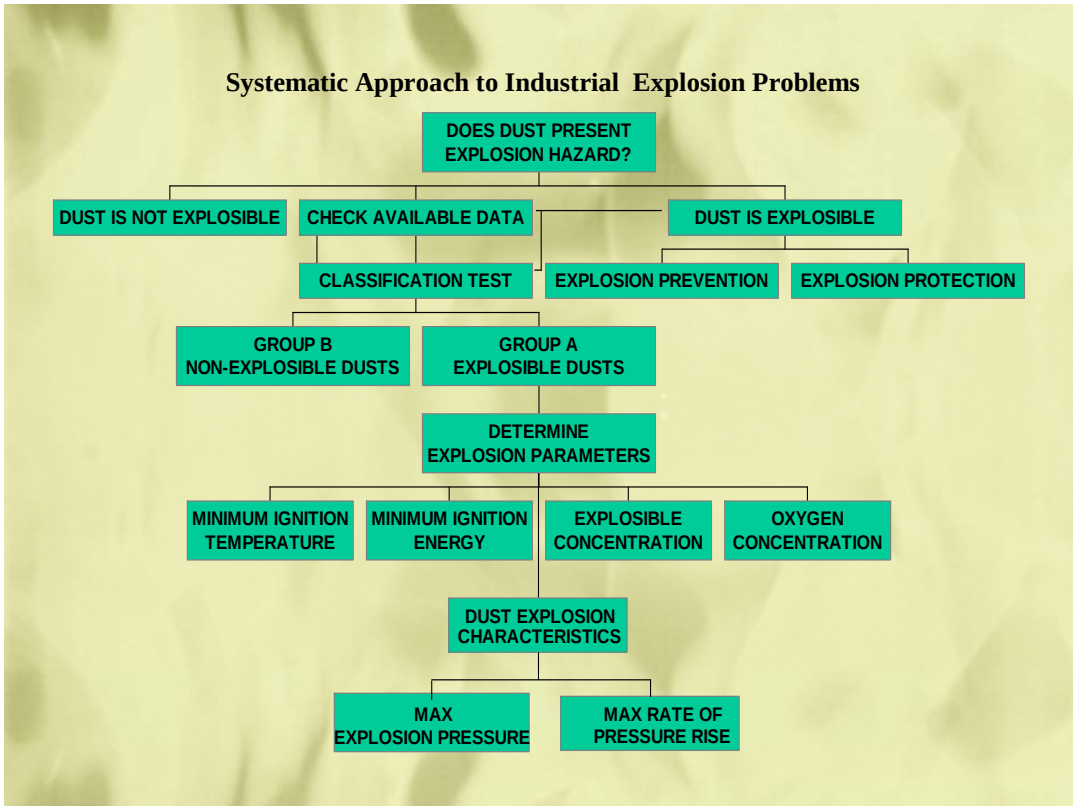


Figure 3.5: Example of zoning for flammable dusts

Typical dust guidelines: Inside equipment;> 0.1 kg dust particles < 0.1 mm or > 1 kg dust particles 0.1<> 0.5 mm. Outside equipment > 50 kg dust particles < 0.1 mm (LEL 30-60 g/m³ => >>1000 m³ exposable dust cloud- Note you can see your hand at the end of your arm at 30 g/m3!) > 500kg dust particles 0.1 <> 0.5 mm

When considering your hazard you should carry out some simple steps. Do you have a hazard at all; check generic data or industry sources. If you cannot find the appropriate data then a classification test is required. If your product already is a proven hazard then you need to quantify the characteristics of the hazard and if protection systems are necessary, you need the extent of the explosion Pmax and KST. All of these parameters have to be relative to the process and condition of your equipment.


Systematic Approach to Industrial Explosion Problems
DOES DUST PRESENT EXPLOSION HAZARD?
DUST IS NOT EXPLOSIBLE
CHECK AVAILABLE DATA
DUST IS EXPLOSIBLE
CLASSIFICATION TEST
EXPLOSION PREVENTION
EXPLOSION PROTECTION
GROUP B NON-EXPLOSIBLE DUSTS
GROUP A EXPLOSIBLE DUSTS
DETERMINE EXPLOSION PARAMETERS
MINIMUM IGNITION TEMPERATURE
MINIMUM IGNITION ENERGY
EXPLOSIBLE CONCENTRATION
OXYGEN CONCENTRATION
DUST EXPLOSION CHARACTERISTICS
MAX EXPLOSION PRESSURE
MAX RATE OF PRESSURE RISE

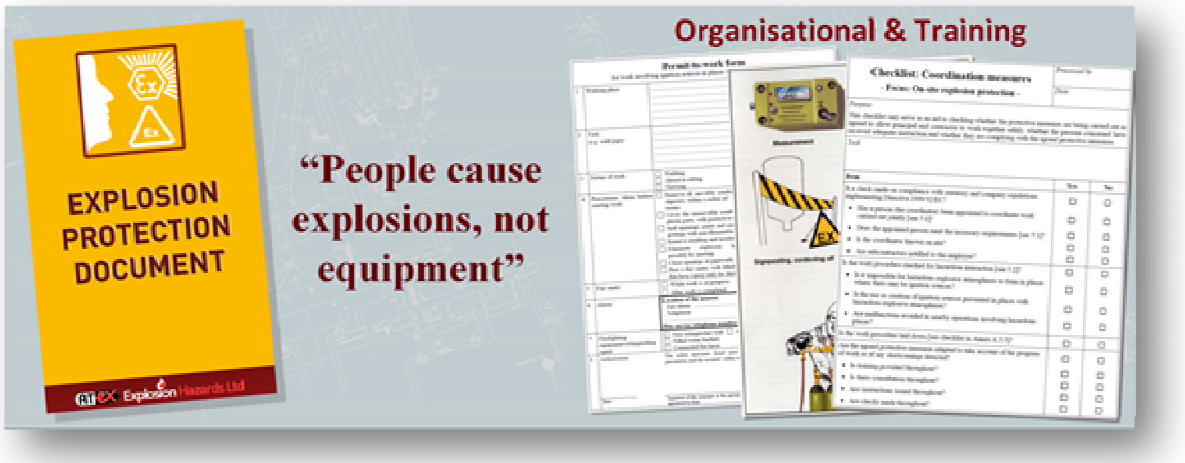
Categories in their respective Zones:

Manufacturer requirements 'ATEX 95' - 94/9/EC	User Requirements 'ATEX 137' - 99/92/EC
Definition of area of use of equipment, specification of equipment group/category	Determination of Zones in plant Select appropriate equipment
Category 1: Category 2: Category 3:	Zone 0/20 Zone 1/21 Zone 2/22
Comply with essential safety and health requirements or relevant standard	Comply with installation and maintenance requirements
Carry out a risk / ignition hazard assessment of equipment	Carry out a risk assessment of the work place
Prepare Conformity documentation	Prepare an Explosion protection document
Appropriate quality control	Regular updates

Explosion Protection Document (EPD):

As one of his duties under Article 4 of Directive 1999/92/EC, the *employer* must ensure that an explosion protection document is drawn up and kept up to date.
This document must at least demonstrate:

- that the explosion risks have been determined and assessed;
- that adequate measures will be taken to attain the aims of the Directive;
- those places which have been classified into *zones*;
- those places where the minimum requirements set out in Annex II to the Directive will
- apply;
- that the workplace and work equipment, including warning devices, are designed, operated
- and maintained with due regard for safety;
- that, in accordance with Council Directive 89/655/EEC, arrangements have been made for the safe use of work equipment.



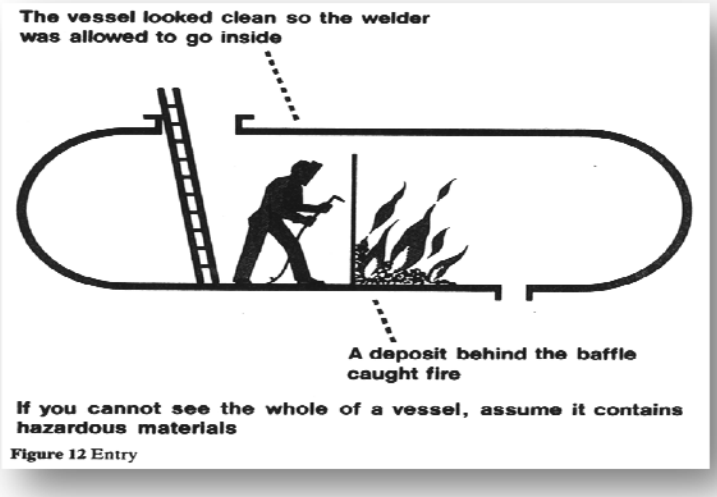
The explosion protection document must be drawn up prior to the commencement of work and be revised when the workplace, work equipment or organization of the work undergoes significant changes, extensions or conversions.
The *employer* may combine existing risk assessments, documents or other equivalent reports and incorporate them into the explosion protection document.

The Directive allows the Explosion Protection Document to be either a separate document or part of a combined safety report and as a whole must cover both technical and organisational or procedural aspects of explosion prevention and protection. Thus for the majority of process plant, it is recommended that these two aspects be separated and dealt with in different documents.

Technical content of the explosion protection document

- Description of each process & plant
- The Fire and explosion characteristics of materials dusts, vapours and gasses.
- Occurrence of flammable atmospheres - Zoning
- Identification of possible ignition sources - selection of equipment
- Risk assessment - i.e. discussion and justification of the measures taken.
- Preventative and protective measures specific to this process or plant.
- Technical/ organisational measures

It can be seen that the technical aspects of the explosion protection document mirror the contents of a traditional fire and explosion hazard assessment which the majority of manufacturers using flammable/exposable materials already carry out.

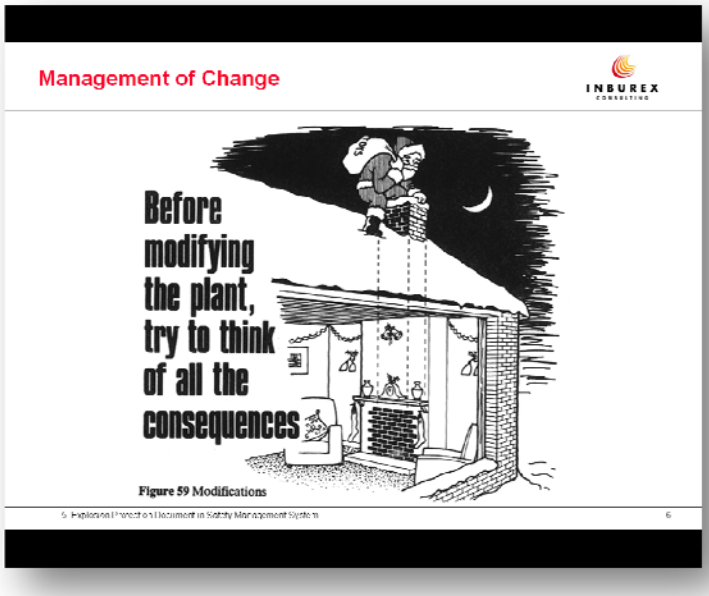

The vessel looked clean so the welder was allowed to go inside
A deposit behind the baffle caught fire
If you cannot see the whole of a vessel, assume it contains hazardous materials
Figure 12 Entry

7 Cranford court
Woolston,
Warrington,
Cheshire
WA14 RX, UK

Safety management aspects of the explosion protection document

Many of the organisational requirements which need to be demonstrated under the ATEX 137 Directive will or should be already be documented as part of a safety management system. Written procedures should be in place for common activities which include:

- SHE Policy /Responsibilities
- Management of change
- Permit to work
- Procedures for visitors / subcontractors. Instructions / training
- Frequency of review etc.



The Position in UK and Ireland

All businesses are required no matter what size to comply with the above. The ATEX 137 has been brought into legislation in the UK by the Dangerous Substances and Explosives Atmospheres Regulations (DSEAR) 2002 No. 2776, DSEAR (pdf link)

There is a very good short guide to the DSEAR see "How safe is your workplace?"
This leaflet provides practical advice to employers (particularly those with small and medium-sized businesses), and the self-employed, about the basic requirements of the DSEAR 2002.

If you want to ensure you are in compliance with DSEAR in the UK, the HSE has issued a set of Approved Codes of Practice (ACOP's) see: HSE BOOKS insert DSEAR in the search engine and order the book(s) on line, These have a special legal status and if you are prosecuted for a breach of Health and safety and you have not complied with these ACOP's, then the court will find you at fault! There is concise help in the non-binding guidance to ATEX 137, on the employer ensuring that an explosion protection document is drawn up and kept up to date with the information required below.
Ditto if you purchase their "Safe handling of combustible dusts" this guidance is not compulsory and you are free to take other action, but if you do follow the guidance you will normally be doing enough to comply with the law.

To comply you must:

- carry out a risk assessment of any work activities involving dangerous substances
- provide measures to eliminate or reduce risks as far as is reasonably possible
- provide equipment and procedures to deal with accidents and emergencies
- provide information and training to employees
- Classify places where explosive atmospheres may occur into zones and mark the zones where necessary.
- Many of the standards and guidance documents for ATEX are still on the drawing board. There are now further work being done on special conditions like bucket elevators, Flame diverters, and small and large vessels. Since the introduction of ATEX in Europe we have seen many mirror activities in the USA NFA and CSB, Russia and worldwide IECEx.

My last comment on this new challenge is that more than 2000 incidents of gas, mist and dust/air atmospheres occur annually in Europe, causing injuries, loss in production, plant damage and even death. This is not acceptable and the introduction of the ATEX regulations should be welcomed.
There are many organisations suddenly offering products and services which can help you through this, but make sure they are reputable with a history in explosion prevention and protection.
The ATEX exercise should be programmed and carried out by the employers with their employees to make industry a safer and more profitable experience.

Explosion Protection
ATEX Simplified

White Paper brought to you by

Explosion Hazards Ltd

For more information, visit us at http://www.explosionhazards.co.uk/

7 Cranford court
Woolston,
Warrington,
Cheshire
WA14 RX, UK